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PHYSICAL CHEMISTRY.—*On a supposed allotropy of copper.* G. K. BURGESS and I. N. KELLBERG, Bureau of Standards.

Some dilatometric experiments have been carried out recently by Professor Ernst Cohen and W. D. Hulderman[1] which have led them to the conclusion that copper exists in two allotropic (enantiotropic) forms, having a transition point at 71°.7 C. to 69°.2 C. under varying conditions of fineness and previous contact with an electrolyte. The copper was in the form of metal chips turned from sticks that had been cast in asbestos from Kahlbaum remelted electrolytic copper. The metal therefore probably contained some cuprous oxide.

Messrs. Cohen and Hulderman also consider the change in the zero value of electrical resistance of copper after heating to 100°C. an *a priori* indication of the probability of allotropic modifications between 0° and 100°C. This phenomenon of shift of zero is, however, common to all metals and is known to be related to the degree of hardness of the metal. It is very persistent, being removed only by complete annealing and freedom from strains.[2]

In Table I are given a comparative series of measurements at 0° and 100° for copper and platinum wire resistance thermometers, wound on the same frame. It will be seen that the plati-

[1] Proc. Amsterdam Acad. **16**: Dec. 27, 1913; **17**: May 30, 1914; Phys. Chemie **87**: 419. 1914.

[2] See for example the behavior of Pt and Pd resistance thermometers, Waidner and Burgess, Scientific Paper No. 124, Bureau of Standards.

num is no more constant in its behavior than the copper, and constancy is attained for both metals after a few heatings to 100°C. If they were now heated to a temperature higher than 100°C., their zeros would again change, and so on.

TABLE I

CONSTANCY OF ZERO RESISTANCE OF PLATINUM AND COPPER

Pt ice	Cu ice	Pt steam	Cu steam
Ohms	*Ohms*	*Ohms*	*Ohms*
3.1600	6.3232		
3.1604	6.3228	4.5222	8.7917
3.1607	6.3212	4.5226	8.7924
3.1612	6.3223	4.5233	8.7920
3.1615	6.3223	4.5233	8.7924
3.1619	6.3221	4.5236	8.7920
3.1620	6.3220	4.5236	8.7922
3.1619	6.3220	4.5237	8.7921
3.1620	6.3221	4.5236	8.7920

Professor Cohen also considers the specific heat experiments of Le Verrier[3]—who found discontinuities at about 360°, 575° and 775°C. from a very limited number of as yet unconfirmed observations—to strengthen his conclusions as to two modifications of copper.

In 1907, Professor Benedicks[4] showed that a supposed allotropic form of copper discovered by Schützenberger[5] was not copper.

In view of the manifest importance of an allofropic phenomenon in copper below 100°, if it really exists, we have executed a series of experiments by an electric resistance method, in the range 0 to 100°C., similar to that described by us for iron,[6] substituting a calorimeter for the furnace.

[3] Cohen, Trans. Faraday Soc., May 1915; Le Verrier, Comptes Rendus **114**: 907. 1892.

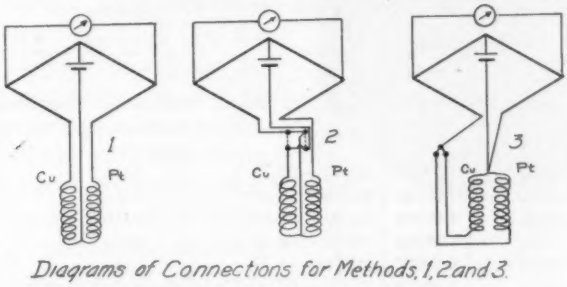
[4] Carl Benedicks, Metallurgie **4**: 5, 33. 1907.

[5] Schützenberger, Comptes Rendus **86**: 1265. 1878.

[6] Burgess and Kellberg, The Electrical Resistance and Critical Ranges of Pure Iron, Scientific Paper No. 236, Bureau of Standards, and Journ. Wash. Acad. Sci. **4**: 436. 1914.

These experiments gave us negative results. A brief description of the methods used and a summary of the results obtained may, nevertheless, be of some interest.

The copper was in the form of hard drawn wire, of 0.005 cm. diameter by about 35 cm. length, wound, together with a platinum wire of 0.015 cm. diameter, on a mica frame and enclosed within a glass tube. This was immersed in a completely water-jacketed and electrically-controlled calorimeter[7] the temperature



Diagrams of Connections for Methods 1, 2 and 3.

Fig. 1. Methods of resistance measurement.

of which could be made to vary uniformly at any desired rate between 0° and 95°C.

Three methods of measurement were used, as illustrated in figure 1:

1. The resistance of the platinum and copper coils was measured differentially and simultaneous observations of temperature were taken with a mercury thermometer. The copper-platinum thermometer was first annealed for 2 hours at 100° and then for 5 hours at 150°C.

2. Using the same copper and platinum coils, a commutator was inserted, as shown in figure 1, which permitted taking alternate readings of the platinum resistance, which then served as a thermometer, and of the platinum-copper resistance difference. In this series of observations the glass container was evacuated, to eliminate extraneous temperature influences caused by convection down the containing tube.

[7] H. C. Dickinson, Bulletin Bureau of Standards **11**: 210. 1915.

3. In a third series, the platinum and copper resistances were measured separately with a common lead and a common battery lead, (as in the observations on iron) and the times taken to 0.1 second on a chronograph. For this series a new length of previously annealed copper wire was used which also received the preliminary alternate heating and cooling shown in Table I.

TABLE II

MEASUREMENTS OF COPPER RESISTANCE

DATE	RATE DEG./SEC.	RANGE DEG. C.	METHOD (SEE FIG. 1) AND REMARKS
Dec. 18, 1914.....	0.00414	84.00 - 67.69	1. Differential resistance. Temperature by mercury thermometer
Dec. 18, 1914.....	0.00362	20.55 - 85.77	ditto
Dec. 19, 1914.....	0.00516	63.18 - 86.40	ditto
Dec. 19, 1914.....	0.00284	76.69 - 57.08	ditto
Dec. 21, 1914.....	0.00096	59.79 - 73.25	ditto
Dec. 22, 1914.....	0.00355	26.73 - 54.55	ditto
Sept. 6, 1915.....	0.00138	57.2 - 68.2	2. Differential resistance. Temperature by Pt. thermometer. Coils in vacuo
Sept. 6, 1915.....	0.00180	67.1 - 58.4	ditto
Sept. 10, 1915.....	0.00039	57.2 - 63.8	ditto
Sept. 13, 1915.....	0.00067	56.2 - 68.0	ditto
Sept. 13, 1915.....	0.00160	66.5 - 57.0	ditto
			Heated for 16½ hours at 130°C.
Sept. 14, 1915.....	0.00213	72.0 - 59.5	2. Differential resistance. Temperature by Pt. thermometer. Coils in vacuo
Sept. 14, 1915.....	0.00058	60.0 - 69.0	ditto
Oct. 22, 1915.....	0.00076	62.0 - 73.5	3. Resistance of copper vs. temperature. Temperature by Pt. thermometer
Oct. 23, 1915.....	0.00226	72.0 - 59.8	ditto

The thermometer leads were of gold for the third series and of copper for the other two. The Wheatstone bridge used was one specially designed for calorimetric work[8] and, as used, accurate and sensitive to 1 in 500,000. Observations were taken every

[8] Bulletin Bureau of Standards 11: 571. 1915.

few seconds, often as close together as 0.03°C. The copper was examined microscopically by Mr. Rawdon and showed a small quantity only of cuprous oxide inclusions, see figure 2.

In Table II is given a list of the ranges over which observations were taken, together with the mean rate of heating or cooling. Several series were taken in the range 60–70° by the second method, as there were apparent indications, from the observations by the first method, of a possible resistance effect. This was, however, attributed to convection since it was not constant in position and could be introduced at will by opening a window or door in the laboratory. In the second and third methods no anomaly could be detected, to at least 1 part in 50,000. The last series taken

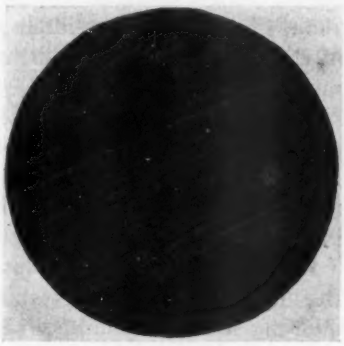


Fig. 2. Photomicrograph of longitudinal section of copper wire.

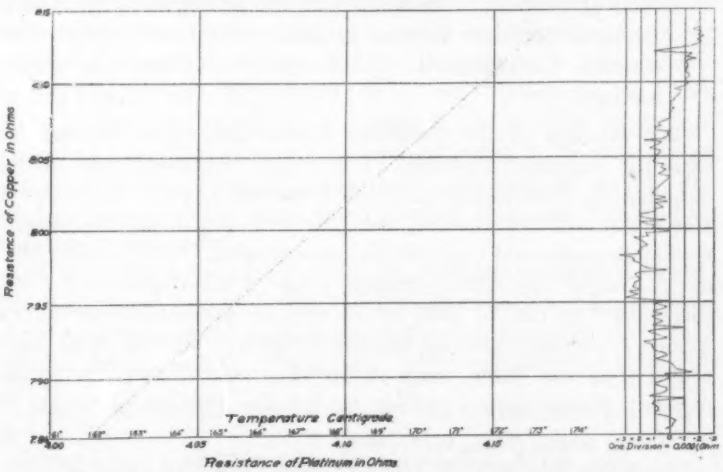


Fig. 3. Resistance of copper vs. platinum and plot of residuals.

is reproduced in figure 3 in the form of a copper vs. platinum resistance curve and also as a curve of residuals. The plot of residuals was constructed from the platinum-copper resistance curve, using a straight line as reference on cross section paper 165 x 140 cm. The residual plot is slightly curved on account of the slightly different resistance-temperature relations of platinum and copper.

We may, therefore, conclude that an allotropic transformation of copper at about 70°C., postulated by Messrs. Cohen and Hulderman, does not exist; that the resistance of copper in the range of 0° to 100° varies continuously; and that ordinary copper is most probably not in a metastable state.

It may not, perhaps, be out of place to remark in conclusion, that it is extremely regrettable that such a far reaching and disquieting announcement as the metastability at ordinary temperatures of a metal so widely used and extremely important in exact measurements, should be made on the basis of two or three series of very inconclusive measurements.

MEDICAL ZOOLOGY.—*Identification of the stages in the asexual cycle of* Bartonella bacilliformis, *the pathogenic organism of verruga, and their bearing on the etiology and unity of the disease.* CHARLES H. T. TOWNSEND, Bureau of Entomology.

The etiology of the Peruvian disease known as verruga has thus far remained obscure. The writer considers that he has conclusively demonstrated *Phlebotomus verrucarum* Townsend as the vector of this disease, but the true status of the specific organism concerned is as yet undemonstrated. Barton described as "x-bodies" the mature gamete stage of this organism in 1909, discovered by him in 1905 in the erythrocytes of the peripheral blood of verruga cases in the fever phase.[1] Strong et al. have redescribed the same stage under the name *Bartonella bacilliformis*,[2] which they consider to be the specific organism of

[1] Crónica Médica (Lima) **26**: 7. 1909.

[2] Journ. Am. Med. Assoc. **61**: 1713–1716. 1913; Rep. First Exped. So. Amer., Harv. Sch. Trop. Med., 32. 1915.

"Oroya fever" (fever phase of verruga), while they consider "verruga peruviana" (eruptive phase of verruga) to be a distinct disease. It is the purpose of the present communication to interpret correctly the stages in the asexual cycle of the pathogenic organism from the findings already published, the significance of which has not yet been fully pointed out. These published findings will be taken up in chronologic order.

In 1911, Darling figured gametes found by him in verruga blood smears from Peru, among which he gives a figure of an erythrocyte filled with minute rods which he terms "young x-bodies," and which will be referred to as Darling's x-bodies.[3] These are the immature gametes of *Bartonella*, shortly after penetration of the erythrocyte.

In September, 1912, Gastiaburú and Rebagliati, working in Lima, Peru, discovered certain "cuerpos" (bodies) in verruga eruption tissue and in liver of verruga patients in the eruptive phase, which they figured and described as *Leishmania*-like.[4] These "cuerpos" are respectively early and maturing schizonts of the *Bartonella* before they have begun to break up into merozoites.

In April, 1913, Mayer, Rocha-Lima and Werner, working in Hamburg, figured and described certain "Zelleinschlüsse" (cell-inclusions) which they found in vascular endothelial cells of the greater part of the verruga nodules examined by them from a case of the disease just arrived from Peru.[5] Their figures 1 to 4 show the cell-inclusions entire, while 5 and 6 show them ruptured. These "Zelleinschlüsse" are evidently to be interpreted as, respectively, maturing *Bartonella* schizonts (1 to 4), and *Bartonella* merozoites which have resulted from the breaking up of schizonts (5 and 6).

In 1915, Strong et al. figured and described certain "spheres" found by them in endothelial cells of spleen and lymphatic nodes of verruga patients in that phase of the disease which they term "Oroya fever," which spheres they state apparently "break up

[3] Proc. Canal Zone Med. Assoc. **4**: 208–209. (No. 6, Case I, right-hand figure.) 1911.

[4] Crónica Médica, **29**: 651. 1912; Journ. Econ. Ent., **6**: 224. 1913.

[5] Münch. Mediz. Wochenschr. **60**: 740. April, 1913.

into a large number of minute elements each of which contains a chromatin granule; these become elongated and finally appear as distinct rods containing at one end a minute particle of chromatin."[6] These "spheres" are obviously an earlier stage of Mayer, Rocha-Lima and Werner's "Zelleinschlüsse;" of this the writer believes there can be no doubt. Figures 1 and 2, plate X, of Strong et al. are early schizonts of the *Bartonella* and the same as Gastiaburú and Rebagliati's eruption "cuerpos;" corresponding more or less nearly to 2a and 3a in Gonder's diagram of the life-cycle of *Lymphohaematocytozoon parvum*,[7] reproduced for purpose of comparison by Strong et al. as figure 1, plate XI. Figure 3, plate X, of Strong et al. corresponds to Mayer, Rocha-Lima and Werner's figures 1 to 4, and to Gastiaburú and Rebagliati's liver "cuerpos;" figures 4, 5, and 7, plate X, represent the elongated stage of the merozoites, somewhat farther advanced than the stage shown in figures 5 and 6 of Mayer et al., though signs of elongation are apparent in the latter's figure 5. Strong et al. add: "If these rod-shaped elements, which have been set free by the rupture of the endothelial cells, are compared with the rods found within red blood-corpuscles lying near, it is seen that they are identical in character. Moreover they are entirely similar to the forms already observed in the blood-cells in the peripheral circulation."[8] These "rods" or "rod-shaped elements," prior to their penetration of the erythrocytes, are to be considered as merely an advanced stage of the merozoites; immediately after entering erythrocytes, and before completing growth, they are to be considered as immature gametes, and are the same as Darling's x-bodies. The work of Strong et al. has thus resulted in establishing a definite connection between Barton's x-bodies, Darling's x-bodies, Gastiaburú and Rebagliati's "cuerpos," and Mayer, Rocha-Lima and Werner's "Zelleinschlüsse," which was hitherto not apparent.

All of these findings appear to indicate conclusively that the *Bartonella* is a protozoan. Several facts, which are easily ex-

[6] Rep. First Exped. So. Amer., Harv. Sch. Trop. Med., 33. 1915.
[7] Journ. Comp. Path. and Ther. **23**: 328. 1910.
[8] Rep. First Exped. So. Amer., Harv. Sch. Trop. Med., 33. 1915.

plicable, have proved stumbling-blocks, however, in interpreting the asexual development of the organism. It has been repeatedly demonstrated that blood containing the *Bartonella* gametes in the erythrocytes fails to originate any symptoms upon injection into healthy animals; that the gametes disappear from the erythrocytes upon the advent of the eruption; that eruption-tissue inoculations produce localized lesions in new tissues without *Bartonella* gametes in the erythrocytes; and that such lesions may be produced successively in series of animals by such inoculations. These and related facts are what induced Strong et al. to consider the fever and eruptive stages of verruga as two distinct pathologic entities.[9] But their finding in "Oroya fever" cases of the schizonts and merozoites, already shown to be characteristic of the eruption tissues, appears to bind inseparably their "Oroya fever" and "verruga peruviana" as phases of one disease. The explanation of the several facts above mentioned will appear below.

It is apparent that the great majority of the *Bartonella* sporozoites introduced by the *Phlebotomus* within the skin of susceptible subjects immediately imbed themselves in the cytoplasm of the vascular endothelial cells at point of inoculation, becoming schizonts, which upon maturing break up into merozoites, these elongating within the unruptured host-cell wall and penetrating such erthrocytes as come in actual and direct contact with the infected cell, whereupon they become immature gametes. The fully formed rods and ovals in the erythrocytes are respectively the mature male and female gametes, which can conjugate only in the *Phlebotomus*. Hence their injection into a healthy warm-blooded animal fails to originate any symptoms of the disease. There appears to be no duplication or repetition of any of the stages, except that the male gametes increase by binary transverse division.

The endothelial cells of the capillaries of the subcutaneous tissues are evidently the chief seat of the above-described schizogonic cycle of the Bartonella, and here is where the erythrocytes become infected.

[9] Ibid., 6, 14, et seq.

The beginning of the fever stage doubtless follows the extensive breaking up of the schizonts in the endothelial cells of the capillaries, and coincides with the extensive penetration of the erythrocytes by the merozoites.

The eruption, which is particularly characterized by a great proliferation of vascular endothelial cells, is the direct result of the extensive asexual multiplication of the Bartonella in the subcutaneous tissues. The proliferation of vascular endothelial cells prevents the erythrocytes from coming in direct contact with cells containing merozoites. Hence the infection of the erythrocytes is cut short, the fever subsides, and the gametes are no longer to be found in the blood. Hence also eruption-tissue inoculations produce no gametes in the erythrocytes of the subject inoculated, for the merozoites contained in such material are obviously unable to come in contact, under proper conditions, with the erythrocytes in the new tissues.

Erythrocytes can evidently become infected only during their slow passage through the capillaries and while in contact through positive chemotropism with a living infected endothelial cell in situ in the capillary wall. Eruption-tissue inoculations are, in a sense, mere transplantations, or grafts, as proved by the fact that the resultant proliferation is strictly localized. They are comparable in behavior to the grafts of carcinoma and other tumors which have been effected within recent years.

The cause which leads to localized proliferation in new tissues following such inoculations appears to be purely mechanical in character, the new proliferation resulting from a specific irritation of the endothelial cells in the capillaries of the new tissues by the proliferated cells thus introduced. Such new proliferation may be successively repeated by inoculation of old proliferated cells into new tissues. This explains the lesions obtained by Strong et al. in twelve series of monkeys, which they considered due to a virus resident in the proliferated tissues used for inoculation.[10] But they were unable to obtain lesions by injection of a filtrate from these tissues;[11] nor were they able to cultivate the virus

[10] Ibid., 122 and table II.
[11] Ibid., 125–127 and table I.

which they supposed to exist.[12] It is further very significant that inoculation of these tissues upon the rabbit's cornea produces no lesion.[13] The lesions produced by these inoculations are toxin-incited, not virus-incited. The original proliferation, incited by a toxin resulting from the metabolism of the organism, possesses a specific chemophysical reaction, transmissible within limits to the new proliferation which it induces.

The sporozoites must also reach the spleen, lymphatic nodes, bone marrow, and liver, as well as the capillaries of the mucous membranes, carried thence by the lymphatic system on their failure to imbed in the subcutaneous tissues. If this happens extensively, internal eruption results. This explains the infarction, necrosis, etc., of the internal organs mentioned, and the articulation and bone pains, so commonly noted in the disease. In most cases the fever and eruptive phases of verruga correspond very faithfully in intensity. When this correspondence is not so marked, antibodies have probably aided in greater degree in cutting short the asexual multiplication of the *Bartonella* in the subcutaneous tissues.

It appears that we are now, for the first time, getting some tangible evidence as to the etiology of verruga. Those familiar with the facts so far known relating to this unique disease will at once see how perfectly they all fit together, now that we interpret the cell-inclusions of the eruption tissues as a part of the schizogonic cycle of *Bartonella*. Thus the unity of verruga appears to be demonstrated by the known stages of its specific organism.

[12] Ibid., 125–126.
[13] Ibid., 130.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOPHYSICS.—*General results of the work in atmospheric electricity aboard the "Carnegie," 1909–1914.* L. A. BAUER. Proc. Am. Phil. Soc., **54**: 14–17. 1915.

A paper presented at the annual meeting of the American Philosophical Society at Philadelphia on April 24, 1915. It contains a general account of the progress made by the Department of Terrestrial Magnetism of the Carnegie Institution, in its work in atmospheric electricity aboard the *Carnegie* and at the laboratory in Washington. The Department can now enter actively, with increased facilities, upon participation in another world-wide project, namely, the mapping of the Earth's electric field and the study of its variations at fixed points.

J. A. F.

TERRESTRIAL MAGNETISM.—*Distribution of the magnetic declination in the United States for January 1, 1915, with isogonic chart and secular change tables.* D. L. HAZARD. U. S. Coast and Geodetic Survey Special Publication No. 33, Serial No. 18. 1915.

The general distribution of the magnetic declination in the United States on January 1, 1915, is shown graphically by means of an isogonic chart, on which the lines of equal declination are drawn for each degree. It is based on about 6000 values of the magnetic declination, including about 800 in Canada and 300 in Mexico and the West Indies. In order that the results represented may be used for other dates than the epoch of the chart, tables are given showing the secular change of the magnetic declination at one or more places in each State from 1750 or the date of the earliest observations to 1915. In addition the values of annual change of declination for 1915 are shown graphically on the chart by means of lines of equal annual change. On account of the large number of results available, it was impossible to represent all of

the irregularities of distribution by continuous lines, hence the plan was adopted of drawing the lines to represent the general distribution and of entering on the chart isolated abnormal values differing by more than a degree from the normal value for the locality. A disturbed area of some extent, indicated by observations at several places, is represented by a small closed curve. For this reason the lines on this chart appear less irregular than those on the one for 1910 which it supersedes. D. L. H.

GEODESY.—*Application of the theory of least squares to the adjustment of triangulation.* OSCAR S. ADAMS. U. S. Coast and Geodetic Survey, Serial No. 9, Special Publication No. 28. Pp. 220. 1915.

This publication has not been prepared with the idea of displacing the textbooks in dealing with the subject of least squares but of supplementing these in the special field of triangulation. Concrete examples of adjustments are given, ranging in difficulty from some of the easiest to those that are more difficult. A development is given, expressed in the symbolism employed in the office of the Survey at the present time, for the condition equations necessary to effect the closure in geographic positions of a loop. A need for this has been felt for some time past. A method of adjustment by the variation of the geographic coordinates (latitude and longitude) of the various points has been developed and applied to the adjustment of several figures. This is a method which has not heretofore been used in the United States, although something similar is regularly employed in Canada.

At the end of the publication there is given a new development of the formulas for the computation of differences of elevation from the observations of zenith distances. These formulas take into account some of the effects due to the lengths and heights of the lines that were not taken into consideration in the development previously in use in the Coast and Geodetic Survey. O. S. A.

MINERALOGY.—*An arrangement of minerals according to their occurrence.* EDGAR T. WHERRY and SAMUEL G. GORDON. Proc. Acad. Nat. Sci., Philadelphia, **1915**: 426–457. Aug. 24, 1915.

The types of mineral occurrence are classified on the basis of chemical and geological relations, the chief criterion for subdivision being dissimilarity in mineral content. About 800 species of minerals are arranged according to this classification, and an alphabetical index for locating the position of any species is given. E. T. W.

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